
Kayla Baker
Western Oregon University

Follow this and additional works at: https://digitalcommons.wou.edu/honors_theses

Recommended Citation
https://digitalcommons.wou.edu/honors_theses/196

This Undergraduate Honors Thesis/Project is brought to you for free and open access by the Student Scholarship at Digital Commons@WOU. It has been accepted for inclusion in Honors Senior Theses/Projects by an authorized administrator of Digital Commons@WOU. For more information, please contact digitalcommons@wou.edu, kundas@mail.wou.edu, bakersc@mail.wou.edu.
Why Art Matters in an Increasingly Analytical World
Artistic Means of Communicating Scientific Concepts

By
Kayla Marie Baker

An Honors Thesis Submitted in Partial Fulfillment of the Requirements for Graduation from the Western Oregon University Honors Program

Dr. Karen Haberman
Thesis Advisor

Dr. Gavin Keulks,
Honors Program Director

June 2019
Acknowledgements

This thesis would not have been possible without the following people:

Karen Haberman, for your professional support and guidance, and your enthusiasm for the project which rivaled my own.

Gavin Keulks, for the advice, encouragement, advising, pep talks, pun and joke filled emails, and the constant reminder that this thesis doesn’t have to complete the conversation. And for letting me cry in your office.

The friends who put up with hearing about my project, and provided much needed advice and perspective (and occasionally much needed mocking and sarcasm).

Sharon Follingstad, for being my mentor, my inspiration, my hero. Your artistic experience, and your perspective on the artistic process (and life) is invaluable. Without you and you patience in teaching me, I would never have made it this far. Thank you friend.

My mom, without whom this project would never have been started, let alone finished. Thank you for the advice, the coffee, the hugs, the proofreading, and the millions of things that you’ve taught me. Thank you, Mom: you are my guidepost for everything.

My dad, for teaching me the importance of doing work that you can be proud of, for reminding me that there is an entire world out there still to explore, and for pushing me to always be better. There are still so many adventures to be had, thank you for giving me the courage to pursue them.

My baby brother, for always being so much cooler than me, for reminding me of everything good in the world, and for always being up for a fight. I love you.
Table of Contents:

Acknowledgements 2
Abstract 4
Review of Literature 5
The History of Art in Science 5
Splitting of Science and Art 15
Making the Case for Art-Science Connections 18
STEAM Education in the United States 21
Artistic Means to Further STEAM Fields in the United States 31
Artist Statement 33
Introduction 33
Visual Art Piece 34
Movement Art Piece 37
Written Art Piece 38
The Use of Artistic Pathways 40
Appendices 41
Appendix A 41
Bibliography 42
Abstract

Historically, through the combined forces of scientists and artists, there have been periods of revolutionary discovery and growth in the sciences. However, in today’s society, science and art are often considered separate disciplines and in some instances are even seen as conflicting areas of study. This review examines the current debate of STEM vs STEAM in primary educational settings and the lack of scientific literacy in the United States today, as well as important research on how art can combat public disinterest in scientific research and policy. It discusses the importance of science based art, and the renewal of artistic and scientific collaboration. The artists statement and explanation will review the process of taking a scientific publication and creating three art pieces: a visual art piece, a written art piece, and a movement art piece, all based on the publication “Jellyfish extract induces apoptotic cell death through the p38 pathway and cell cycle arrest in chronic myelogenous leukemia K562 cells”.
Review of Literature

The History of Art in Science

Art has existed as long as humans have been capable of creating it. Some of the earliest examples are the cave paintings in Lascaux, France. The caves contain hundreds of paintings from the Old Stone Age (Leroi-Gourhan, 1982). In the Renaissance, art and science were considered integral to one another. Through the combined forces of scientists and artists, there was a period of incredible discovery and growth in the sciences. This time period saw the invention of technology still used today, such as the microscope and the first telescope, along with Gutenberg’s invention of the printing press. These advancements changed the scientific and artistic communities, and their interactions with the public.

Some of the most well known scientific figures were also artists. To understand the importance of including art in the sciences, it’s important to understand how art has historically shaped scientific discovery. An early example of a famous scientist who integrated art and science was Leonardo da Vinci (1452-1519). His scientific notebooks were filled with inventions, studies of anatomy, and biological observations, many of which were illustrated. Leonardo Da Vinci had many journals full of observations of the human body, explanations of how he dissected cadavers, and mathematical equations for determining the
correct proportions of a human body (Vinci 2011). All of this research, and
discussion and collaboration with fellow scientists, led him to create a drawing,
The *Vitruvian Man*, that is still recognized now, over 500 years later, as an
incredibly realistic and scientifically accurate representation of human anatomy.
This illustration is regarded around the world as an artistic icon, and is notable for
its use of proportion in the depiction of the human form.

*Figure: The Vitruvian Man - by Leonardo da Vinci*
His illustrations of inventions, such as *Design for a Giant Crossbow* (image available at: https://www.davincilife.com/crossbow.html), demonstrate the importance of visual representation of ideas. Although his design was accompanied by a written description: “I will make cannon, mortar and light ordinance of very beautiful and functional design that are quite out of the ordinary. Where the use of cannon is impracticable, I will assemble catapults, mangonels, trebuchets and other instruments of wonderful efficiency not in general use” (Da Vinci as quoted in Baldasso 2011). The accompanying art shows a design that was much more complex than standard weapon design for the time, employing the use of a design similar to the anatomy of bats’ wings. There are concepts that are much better explained visually than through written word, and by illustrating this concept he was able to share it more easily with others.

Not only is the sharing of ideas made possible through art, but it also allows scientists to use pre-existing research and beliefs, and to elaborate upon them. Erasmus Darwin (1731-1802), the grandfather of Charles Darwin, first introduced his concept of evolution in his poem *The Botanic Garden* (*Darwin 1806*). These same concepts were later proposed by Charles Darwin, whose theory of evolution by natural selection is still the foundation of modern ideas of evolution.
Chemist Sir Humphry Davy (1778 – 1829) was well known in his time for his chemistry lectures that featured theatrical elements (such as explosions and demonstrations) and were often loud and unruly. In his work as a chemist, he discovered many elements including: Calcium, Magnesium, Strontium, and Barium (Thomas 2013). He was also known for his poetry regarding his scientific work. One of his earliest poems provides an example of the way he was able to seamlessly combine emotion and observation with the same ideas that would have populated his lab notebooks:

My eye is wet with tears
For I see the white stones
That are covered with names
The stones of my forefathers graves
No grass grows upon them
For deep in the earth
In darkness and silence the organs of life
To their primitive atoms return
Through ages the air
Has been moist with their blood
Through ages the seeds of the thistle has fed
On what was once motion and form (Davy as quotes in Fullmer 2000).
This poem is just one of many that he wrote and shared, and it demonstrates that poetry allowed him to communicate ideas and feelings that, although they didn’t belong in a report or lab notebook, were instrumental in his understanding and connection to his studies. This poem makes mention of returning to atoms, which was well in line with Davy’s focus on the discovery and isolation of different elements.

Naturalists’ studies are also often depicted visually. The saying, “a picture is worth a thousand words,” rings true, as a well-drawn image of a biological creature is often able to express much more clearly the form and function of the living creature than a written description. John Audubon (1785-1851) was an ornithologist, whose work is often regarded as a prime example of this collaboration between art and environmental observations. He told the stories of the birds he watched and sketched and his works were so fascinating to his audience that they are still widely referred to. One such description of an Evening Grosbeak:

“At other times, particularly about mid-day, the male sometimes selects a lofty pine branch, and there attempts a song; but it is a miserable failure, and he seems conscious of it, for he frequently pauses and looks discontented, then
remains silent sometimes for some minutes, and tries it again, but with no better success” (Audubon 2015).

Image: Plate 373 Evening Grosbeak and Spotted Grosbeak, by John Audubon

This short excerpt demonstrates the way Audubon gave personality and life to his ornithological subjects, and even today readers of his plates catch a glimpse of the way he saw the birds that he studied. His illustrations of birds appearing as they had while they were alive allows his audience to feel as if they themselves are catching just a glimpse into the birds’ lives. Unlike many bird artists, Audubon created these lifelike works by killing and stuffing the birds in a
way that allowed him to position them in natural positions, and the plates he created for each specimen often show the birds performing activities like hunting.

Another famous biological illustrator is Ernst Haeckel (1834-1919) who created a genealogical tree connecting the species he discovered and studied in his field of marine biology. Haeckel was fascinated by ideas of evolution and development of species, and his prints of the thousands of new marine species he discovered were collected and published in a book called *Kunstformen der Natur*, or Art Forms in Nature (1899). As a scientific instructor, he was motivated by Charles Darwin’s *Origin of Species*, for although he was a believer in evolution he opposed the idea of natural selection and set out to disprove it (Wellner 2010). His works almost always contained elements of design, and he demonstrates a focus on levels and organization of ideas and species.
Prosobranchia from Ernst Haeckel’s *Art Forms of Nature*
His illustrations may not be considered completely scientifically sound today, as there were some claims he made which remain unfounded, such as his depiction of early embryo stages. However, like many early scientific discoveries that have been adapted and changed to fit the ever changing information we have available, these illustrations demonstrate the need for art and science to be
integrated. This collaboration between fields enabled the scientists to
demonstrate and communicate their ideas, allowed them another mode with
which to explore and clarify their ideas, and assisted others who did not possess
the same level of education to more easily understand and appreciate the
research being done. The use of art in science is not about either artistic
expertise, or complete scientific accuracy, but rather the development and
continued exploration of important concepts, and the artists’ representation of
the importance of the scientific developments.

Splitting of Science and Art

The current attitude regarding science and art in the United States
today exemplifies a profound shift of perspective over the centuries. As society
developed, science and art began to be seen as two separate disciplines, and they
are not only taught separately, but are often seen as disconnected areas of study.
For example, the concept of creating a field focused on Science, Technology,
Engineering, and Math (STEM) was introduced in the 1990s by the National
Science Foundation (Sanders 2009). It was implemented to help the United States
continue to be competitive in industry globally. Although one of the goals of the
program was to develop an educational program that would teach creative
problem solving, along with the technical aspects of the four included fields, STEM in its current form is considered separate from the creative arts.

Art is often considered an emotionally driven pursuit. One example of this belief is seen in the article Jacques Maritain’s Definition of Art, in which the author states, “The emotion that is associated with a thing becomes one with it in the mind of the artist, and he in turn becomes one with the thing, such that he is able to manifest the spiritualised emotion in an artwork, that is both about a thing in itself and the artist’s own emotions about it” (Haynes 2015). Science, on the other hand, is often viewed as a logical and calculating field of study. For example, there was a long standing belief that people were either left-brained or right-brained, based on the idea that “those who are right-brained are supposed to be intuitive and creative free thinkers. They are ‘qualitative,’ big-picture thinkers who experience the world in terms that are descriptive or subjective… Meanwhile, left-brained people tend to be more quantitative and analytical. They pay attention to details and are ruled by logic” (Shmerling 2017). This idea that your personality and characteristics were determined by which hemisphere of your brain was more active does not have enough evidence to be substantiated, but its long standing acceptance by the population demonstrates that people perceive a difference between creative and analytical people.
This societal belief that science and art should remain separate is a serious problem for both scientists and artists. Mae Jemison, the first African American Woman to travel to space, discusses her own issues with this division of the fields. She begins by acknowledging what others may say about scientists and artists, then refutes these views. “‘Scientists and science is not creative. Maybe scientists are ingenious, but they're not creative.’ And then we have this tendency, the career counselors and various people say things like, ‘Artists are not analytical. They're ingenious, perhaps, but not analytical.’ ... By accepting this dichotomy, whether it's tongue-in-cheek, when we attempt to accommodate it in our world... we're messing up the future, because: Who wants to be uncreative? Who wants to be illogical? Talent would run from either of these fields if you said you had to choose either” (Jemison 2002).

Unfortunately, choosing between science and art is a decision that many students feel they must face as they enter upper division educational institutions. In high schools they are often encouraged (or required) to take both art classes and Science Technology Engineering Math (STEM) classes as part of their basic curriculum. However, at a university level students must choose to pursue either creative arts and humanities, or STEM fields. Many universities have programs designed so that a student earning a B.S. takes classes focused in STEM classes, while a B.A. student takes classes based in the humanities and arts.
This is just one of the many ways in which science and art are separated at the university level. This separation occurs both in higher education and professional career fields, despite the fact that science requires creativity and the communication of concepts, and art is often based on the natural world and scientific concepts. Despite this obvious demand for creativity in STEM professions, there are very few chances for scientists to engage in artistic processes directly related to their work.

Making the Case for Art-Science Connections

Worldwide there is currently more scientific research taking place than ever before; however, many of the ideas and information being discovered are simultaneously being made inaccessible to the general population, as they are presented only in scientific papers, written for other professionals in STEM fields. Discussions of vaccination safety, climate change, plastic in oceans, stem cell research, and GMO foods are constantly available to adults in the United States through news outlets and social media. Considering this constant availability to discuss relevant scientific topics that affect most individuals’ daily lives, one may be led to believe that most Americans are scientifically literate. There are many ideas of what constitutes scientific literacy; however, the common theme is that
an individual should be able to understand scientific concepts, and apply these concepts in their daily lives (Cavagnetto 2010).

A recent poll, conducted by the Pew Research Center, asked respondents to answer 12 basic scientific questions. For example, questions asking which layer of Earth has the greatest temperature. The average score among adults in the United States was 65.8%, with only 6% of participants getting all 12 questions right (Pew Research 2015 (a)). It’s not just adults in the United States who struggle with scientific knowledge. The Programme for International Student Assessment (PISA), assesses 15 year olds from 71 different countries to see how they compare in their math, reading, and scientific education. The most recent PISA (conducted in 2015) placed the United States 38th out of the 71 participating countries in average math scores, and 25th out of 71 in average science scores (DeSilver 2017).

Although 54% of adults in the United States believe that as a country the United States has above average scientific achievements compared to other industrial countries (Pew Research 2015(b)) in 2016, only 4.9% of the United States population was made up of professional scientists and engineers according to The Congressional Research Service (Sargent 2017). This illustrates that a large portion of the United States population doesn’t have a background in science.
Despite this lack of scientists in the population, scientific research tends to be presented by scientists, for other scientists, in the form of peer reviewed scientific publications.

While a college education may be necessary to learn the technical aspects of a career, there has been a growing desire of employers for employees who have soft skills. “The shift from an industrial economy to an information society and an office economy means that many jobs now place an emphasis on integrity, communication, and flexibility” (Robles 2012). This desire for communication and flexibility illustrates a need for STEM professionals to be able to creatively problem solve, meet challenges with innovative ideas, and communicate important research and concepts both to other STEM professionals, and to the public. This creativity should be an integrated part of education, from the beginning of a child’s education, throughout higher level education.

Current US scientific public knowledge suggests that the current methods of education in the United States are no longer effective in teaching the material to students. There is a disconnect between the research being done, and the way it is being communicated to non-scientists, and it is important that the scientific community is able to acknowledge this limitation. However, if there is a way to
engage the public in this research, and to develop personal and emotional connections, students will be more invested in their education. Artistic pathways allow for both emotional connection and a better understanding of the significance of the research. The argument for implementation of Art-Science is that in order to be a well-educated society, there must be integration of science and art in education, and in the presentation of STEM to individuals without a science background.

STEAM Education in the United States

The STEM Education Act of 2015 is currently implemented across the US, and provides “competitive, merit-reviewed grants to support: (1) research and development of innovative out-of-school STEM (science, technology, engineering, and mathematics) learning and emerging STEM learning environments; and (2) research that advances the field of informal STEM education” (“H.R.1020” 2015). In 2017 an amendment to that bill was introduced to the House, titled STEM to STEAM Act of 2017. It proposed an amendment to the current legislation, to include awarding grants to support the integration of art and design into STEM educational programs (“H.R.3344” 2018). Since its introduction, it has been referred to the House Committee on Science, Space, and Technology, and then referred to the Subcommittee on Research and Technology. The concept of including an “A” in STEAM (for Arts) is a relatively new one, but the use of art in
collaboration with science has been taking place since the start of scientific research and discovery.

This legislation has spurred a popular STEM vs STEAM debate among higher level educators, although the basis of the argument has been around for much longer than the bills have existed. There is currently widespread support for integrating the arts, as can be seen by the increasing number of STEAM lesson plans available to educators, the introduction of the STEM to STEAM Act of 2017, and the integration of art into higher level education, including doctorate programs. However, there are those, including Gary S May, the chancellor at UC Davis, who believe that STEM should not incorporate the Arts. He published an article in 2015 titled STEM, not STEAM. The article states “The clear value of the arts would seem to make adding A to STEM a no-brainer. But when taken too far, this leads to the generic idea of a well-rounded education, which dilutes the essential need and focus for STEM” (May 2015).

His sentiment is one shared across many blogs and social media posts, most of which share the idea that adding the Arts to STEM would distract from its original intended goal, which was to increase United State investment in STEM subjects to allow us to compete globally in innovation and research. However, this sentiment is not shared by the majority of educators, who are working to
incorporate STEAM into their lessons, from elementary level all the way to
doctorate programs.

If one looks at the number of art and science collaboratory lesson plans for
elementary school through middle school, there are many ideas about how to
allow students to integrate both of these disciplines in their studies. The Public
Broadcasting Service (PBS) has a section of their website dedicated to classroom
lesson plans that integrate both science and art, for example Colorblindness
Lesson Plan teaches students the physiology behind color blindness, and allows
them to explore how their artwork would appear to someone who was colorblind
(“Colorblindness” 2017). In the lesson the students watch a video explaining the
science behind color blindness, and the different types, and then they discuss the
artwork of Charley Hamilton. Then students are challenged to recreate one of his
pieces, but using only the color spectrum visible to an individual who is
colorblind. This gives them a greater understanding both of the scientific and
emotional concepts associated with both color blindness and this style of
artwork.

Exploratorium (https://www.exploratorium.edu) is another resource that
has STEAM lesson plans available to educators, including Cardboard Automata
which guides students through the process of creating a moving sculpture, using simple mechanical elements (“Cardboard” 2018).

Communication of research findings to non-science oriented individuals is a vital skill that many of today’s scientists lack and that needs to be focused on specifically in science education, from elementary school through college education. One important example of how children are taught to work together in science and art took place in an elementary classroom in which science and art students were paired up (Ochterski 2016). The science students would explain scientific concepts and research to their partner, who would illustrate these concepts, focusing on the communication of the main ideas and findings of the research. For example, Chemistry students studied and prepared a report on a molecule of their choosing, including where these molecules would be found, and any unique properties (such as toxicity). The Chemistry students then shared this research with their partnered art student, who took the information about the molecule and created landscape drawings incorporating the location and characteristics of the molecule. The partnered students shared the research and art pieces with each other to allow each of them to see the information represented in different ways.

Ochterski also explained that the more projects the students worked together on, the better each group was able to communicate with the other, and
to work together to create things that were not only artistically appealing but contained scientific significance. The teachers concluded, “Students will benefit from exploring the connections between art and science and gain a broader view of the world around them” (Ochterski 2016). This classroom partnership is one of many examples of scientific and artistic collaboration at the elementary school level. It is becoming widely recognized at elementary levels that art and science should be utilized together when teaching students.

Primary educators are not the only ones integrating STEAM into the classroom. One example of post-secondary STEAM education is The State University of New York at Potsdam. The faculty of the University chose to reimagine the curriculum of the university, to enforce a more comprehensive set of requirements for students. This new curriculum requires them to integrate creative and artistic processes in their STEM classes. Each student recruited for their STEAM Integrated Education program begins their Integrative Core education with a class titled “Creativity and Problem Engagement.” This program of integration allows students to pick an area of focus (similar to a major) and two areas of minor specialization. These students also participate in Integrated Learning Modules (which are run as classes) that allow interdisciplinary teams to work together to come up with creative solutions to real world problems. In addition to these classes that focus on creative problem solving, each class the
students participates in addresses one of the following: communication, collaboration, responsibility, application, reflection, creative learning, problem engagement, synthesis, literacy, and dispositional development. This curriculum change is too recent to analyze for success rates, but the faculty is adamant that “This unique STEAM curriculum will be a model for educating creative scientists who can develop innovative solutions to serious global problems. Once it has been offered and thoroughly assessed, it will be disseminated throughout the higher education community” (Madden 2013). Their dedication to creating a university experience that fosters creativity is an important stepping stone to establishing creativity as a norm in today’s educational establishments.

One medical school (University of Bristol, Bristol Medical School) has started to address this need for creative communication, as they recognize that the way in which physicians are educated can cause problems. The author of the article acknowledges that “medicine has become a practice without subjects: the persons of both doctor and patient having disappeared” (Thompson 2010). They have integrated creativity into the curriculum by having students focus on the patients, and the medical conditions they may be impacted by, and creating art pieces based on the impact that these medical conditions have on an individual’s life. Students employ many different art forms including poetry, painting, sound, photography, and film. These art pieces are shared with classmates, and are
uploaded to a website to be shared with the community. By allowing and encouraging students to empathize with patients, and by demonstrating the importance of connecting to people on an emotional level as well as understanding the etiology behind the disease, the students are better able to explain to patients the science behind their illnesses, and how to go about resolving the issue. Trevor Thompson, who is a teacher at The University of Bristol Medical School, says that “Creativity is not a luxury, it is an essential component of the innovation on which the future of our health services depends” (Thompson 2010). This is a contrast to the way that art and science are often categorized as separate fields of study by universities. This creativity makes them more effective at treating patients, and allows them to properly handle their emotions.

In post-secondary education there is a common concern regarding artistic education in non-artistic based fields, that students will be unwilling to participate, or that students who feel they lack artistic skills will be less invested in the learning taking place, as they feel they can’t actively participate. Thompson addresses this saying: “We stress the idea that we are not looking for artistry, but authenticity,” and suggests that any art that was created from true effort would not be graded harshly, but met with praise and encouragement to continue working creatively. “All these elements serve to create an educational
climate were students are more likely to take the risk of entering unfamiliar territory” (Thompson 2010).

This medical school program serves as a wonderful example of how encouraging art can allow STEM students more practice thinking empathetically, and focusing on how their science education impacts their patients. So far the curriculum has proven successful, and they have started a website (http://www.outofourheads.net) where student artwork is posted, and even used in future classes to demonstrate important ideas. There is something about seeing a peer’s work that can make lecture topics more accessible to current students, and it allows them to create personal connections with the educational material.

These examples of STEAM education shows that there are many educational facilities that have embraced the encouragement of creativity and art in traditionally scientific fields, and as they continue to show their success in these programs, it is likely that other educational institutions will follow suit.

Aside from educational institutions, there are some groups that have embraced a renewed collaboration between science and art. A well-known example among students is the TED Talks programs, which take place across the world. These programs are full of speakers from a wide variety of backgrounds and education levels, and these presenters are able to introduce the audience to
their studies or projects. TED stands for Technology Education Design, and TED talks address everything from psychology to artificial intelligence to spoken word poetry. Many TED presenters are aware of the importance of artistic bridges to scientific understanding. One example of this understanding is Kasha Patel’s presentation on why she uses science based jokes as a stand up comedian, and why humor is an effective tool in introducing scientific concepts to her audience. “I use comedy to make sometimes inaccessible parts of the world more accessible for people sometimes” (Patel 2018). She also notes that often times people will look up the science behind her jokes, which gets her audience more involved with current scientific concepts.

Another example of a TED presenter who uses both science and art in his projects is Thomas Heatherwick, who designs buildings. One of his recent creations was the Seed Cathedral, a structure built for an expo in Japan that was constructed out of 66,000 optical hairs, with seeds displayed at the ends. The purpose of this structure was to highlight the importance of the Millenium Seed Bank, which is collecting and preserving seeds from seed bearing plants around the world (Heatherwick 2011). People were able to interact with the structure, and it brought awareness to the importance of seeds, and served as a reminder to take time to appreciate what surrounds us daily. Another of his projects was the design of apartment buildings in Malaysia. His team designed buildings that
would allow 90% of the space on the ground to functional as space for a rainforest, while maintaining the same number of apartments for the property developers (Heatherwick 2011). This allowed less profitable ground floor apartments to be converted to higher value upper level apartments. These structures are examples of functional art-science, and are one of the many ways that creative problem solving relies on artistic design to develop solutions.

*Image: Thomas Heatherwick’s apartment building design concept*

In addition to innovative problem solving, community science-art programs encourage individuals to participate in the creative expression of their ideas. There is an American Association for the Advancement of Science sponsored community contest called “Dance your Ph.D.,” which encourages
anyone who has completed Ph.D. research to create a dance video explaining the concepts, and outcomes. They are in their 11th year of the contest, and have had submissions on concepts ranging from “sperm competition between brothers and female choice” to “metal fatigue”, to the “effects of sleep deprivation on a person’s daily functions”. The contest guidelines state “All science should be explained with dance” (“Announcing” 2019).

Programs like TED and Dance Your Ph.D. are an important start to the reinforcement of the idea of combined science and arts programs. They allow STEAM professionals from a wide range of fields of study, and the general public, to learn about others’ works, and interact with research that otherwise may have been inaccessible.

**Artistic Means to Further STEAM Fields in the United States**

There is an incredible amount of emphasis placed on scientific research in the United States right now, as we are working on finding renewable fuel resources, developing medications that will prevent or cure a myriad of health issues, and attempting to better understand the impact that we have on the environment around us. Every day there are an infinite number of new problems to deal with, and in order to effectively handle these situations we need scientists who can think of new and creative solutions, and do it efficiently and consistently. We also have a need for artists who can solve scientific problems in a way that
benefits the public, such as the apartments which allow for more space for trees in a busy city. Innovative solutions like this one are only possible through the integration of science and art.

The current idea in the United States that science and art are separate fields of study limits our abilities as a nation to grow and meet new challenges, and it limits communication of scientific ideas to the public. We praise science for being factual, and consider scientists to be interested in the pursuit of the truth and new discoveries. We think of artists as being demonstrators of truth, both emotional and visual, and we praise them for their ability to connect to other people. However, at the base of both science and art is the same thing, the universal experience, and how humans relate to it. As we move forward, it is our responsibility to enact change in our legislation, our educational institutions, and our own personal research, to encourage the growth of art and science as an integrated field. As Jemison stated in her TED talk, “I think our mission is to reconcile, to reintegrate science and the arts” (Jemison 2002).

This need moving forward to reconcile these two fields requires innovative solutions as well. It goes beyond a need to tell people to be more creative in their day to day life, and requires a reconstruction of the way society views art and science. It is only through this renewed excitement about artistic pathways that we will, as a population, grow in our scientific understanding as well.
Artist Statement

Introduction
The second portion of this thesis is devoted to the creation of science-based art pieces. For this portion, I chose a recent publication that had ties to my personal interest in both marine biology, and medicinal science. The article is titled: Jellyfish extract induces apoptotic cell death through the p38 pathway and cell cycle arrest in chronic myelogenous leukemia K562 cells. I began the process of creation by developing a complete understanding of the ideas and concepts presented in the article. This involved extensive annotation of the article, along with additional research of the scientific concepts I was unfamiliar with.

In order to determine which ideas I wanted to convey through the art pieces, I formed a one sentence summary of the paper, and the most important concept it conveyed. For this article it was:

**Extract of poisonous jellyfish was used to cause cell death in cancer cells**

This provided enough detail that it was still specific to the research paper chosen, but it was stated in broad enough terms that I hoped it would still be accessible to individuals without a science background.
**Visual Art Piece**

The visual art piece that I created for this project was advised by a community artist, Sharon Follingstad, who provided both instruction in media that was new to me, and advice on how best to structure the piece of art to most effectively convey the idea of the research. Although originally I experimented with watercolor, the use of mixed media in the form of cut glass and glass paint gave me greater freedom with the representation of ideas. The visual piece of artwork consists of two glass panels. The top panel contains a cut glass depiction of a jellyfish. After careful consideration I chose not to depict a Nomura's jellyfish, although that was what was used in the research, but to use a less specific depiction to allow for the reader to draw their own conclusions about the subject.

The second glass panel, which can be viewed through the first, was created using glass paints. A painting technique was used with the goal of creating both a background that conjured up images of the ocean, while simultaneously representing the shift from leukemia, back to homeostasis. This is demonstrated by the shifting from black and white, representative of the overabundance of white blood cells in myelogenous leukemia, to the blues and purples that would be a return to normalcy for the jellyfish.

Upon completion of this art piece, I recognize that there are ways it could be improved, as I think any amateuer art piece could be. However, I also recognize that it does convey a message, the interpretation of which is influenced by the viewer’s personal experiences.
Movement Art Piece

The movement art piece for this project was by far the most challenging for me as an artist. The creation of this piece would not have been possible without the guidance and input from many individuals with dance experience. The dance was originally choreographed for a group of ten dancers, but due to constraints of time and volunteer availability, it was rechoreographed for two dancers.

While choreographing the dance, my goal was to convey specifically the idea that the leukemia cells were disrupting the cell cycle, and that it was only though the introduction of the jellyfish that normalcy returned to the setting. I chose to have the person portraying the cell move in a regular pattern, the first time the movements were small and more concise, and with each passing cycle they grew more chaotic and free. Then, as the person playing the jellyfish entered, a battle ensues, with the jellyfish fighting to force the cells to return to their original cycle. The choreography I originally developed was created for a group of nine ‘cells’ and one ‘jellyfish’. This would have allowed eight of the dancers who were portraying cells to continue the normal cell cycle, while just one would diverge from the original path. I believe that this would better allow
the audience to understand that the cancer cell was growing more out of control, compared to the ‘healthy cells’. Due to limitations with volunteers’ schedules, I chose to recreate the choreography for two dancers. There is an example of what the choreography could consist of (Appendix A) for two dancers. The more skilled the dancers performing it, the more chaotic the movements in the last cycles could be, including acrobatic elements, to illustrate how out of control the cells involved in cancer are.

Movement art proved to be a great challenge, partly due to my own personal lack of experience, and partly due to the unique challenges involved with directing other artists. However, movements do present opportunities to express actively changing systems, which was more difficult with the other two art forms.

Written Art Piece

The third art form that I used for this project is written art, in the form of poetry. I wanted to focus this piece on the emotional reaction to the article. Most people have a personal connection to cancer, through family members or friends, and it is a difficult and painful topic. My goal was to demonstrate the uncertainty and fear that can be brought about by both cancer, and the ocean. There was
also something striking about the way that it took something deadly, poisonous jellyfish, to effectively fight something else deadly, cancer.

With the help of multiple community members, with a variety of writing backgrounds, I transitioned from writing rhyming poetry to free form poetry, and although this was a difficult transition to make, I feel that it was incredibly beneficial to my ability to express the personal connections, without making the writing feel forced.

**From the Sea**

“Don’t touch the jellyfish” she chides, as the water eats up our sandy footprints behind us. They are strewn across the sand, forgotten playthings of the waves. I never expect the ocean to betray me like that, setting traps along the tideline, opalescent forms luring me in, begging me: ‘take a closer look’. I never expect the ocean to betray me like that. And I never expect my body to betray me like that. The white tiled hospital rooms never leave enough air for me to breath, let alone space for the salty ocean breeze.

The waves have always been home. But danger lurks. Nothing is truly safe. Not the waves. Not my body. Not your body. You were taught not to turn your back on the ocean, but no one warned you about flesh and bone. Too many cells, spilling out of your veins like the rising tide, leaving everything stranded and gasping for air.
So you let go of her hand. Wade into the waves. Yes, the jellyfish are dangerous, but poison already runs through your blood.

**The Use of Artistic Pathways**

Although I am in no way a trained artist, I found this portion of my thesis to be incredibly beneficial both to my understanding of the article, and the ability to share that information with others. By creating these three art pieces, I found that through hours spent with the research content, I developed a personal connection with the publication, and became increasingly more invested in the ideas I wanted to portray through my art pieces.

It was also important to me to be able to spend time with artists from the community, as my own personal background is more scientific, and my time with them taught me so much about artistic processes, and the way with which artists are able to share their own personal views through art pieces. As someone who plans to pursue a career in the STEM fields, this thesis remains important to me both professionally and personally. Moving forward, I would like to believe that the US will see a continued increase of integration between sciences and arts, and that this would allow for community engagement, and increased
communication between STEM and artistic communities. This integration is vital to the renewed public interest in STEM research, and to the engagement of students who are pursuing an education in either field.
Appendices

Appendix A
Bibliography:


Madden, Margaret E. ; Baxter, Marsha ; Beauchamp, Heather ; Bouchard, Kimberley ; Habermas, Derek ; Huff, Mark ; Ladd, Brian ; Pearon, Jill ; Plague,

Maeda, John (2013) "STEM + Art = STEAM," The STEAM Journal: Vol. 1: Iss. 1, Article 34. DOI: 10.5642/steam.201301.34


Project 2061 (American Association for the Advancement of Science). (1989). Science for all Americans : A project 2061 report on literacy goals in


www.health.harvard.edu/blog/right-brainleft-brain-right-2017082512222.
Sun-Hyung Ha, Jin, F., Choong-Hwan Kwak, Abekura, F., Jun-Young, P.,
through the p38 pathway and cell cycle arrest in chronic myelogenous leukemia
K562 cells. PeerJ, doi:http://dx.doi.org/10.7717/peerj.2895

Thomas, J. M. (2013). Sir humphy davy: Natural philosopher, discoverer,
inventor, poet, and man of Action1. Proceedings of the American Philosophical
Society, 157(2), 143-163. Retrieved from

Trevor Thompson, Catherine Lamont-Robinson & Louise Younie (2010)
‘Compulsory creativity’: rationales, recipes, and results in the placement of
mandatory creative endeavour in a medical undergraduate curriculum, Medical
Education Online, 15:1, DOI: 10.3402/meo.v15i0.5394


Wellner, Karen. (2010). "Ernst Heinrich Philipp August Haeckel
(1834-1919)". Embryo Project Encyclopedia. ISSN: 1940-5030
http://embryo.asu.edu/handle/10776/1752.